REMARKS

Claim Rejections - 35 U.S.C. §

The Examiner has rejected claims 1-4, 6-8, 11-17, 19-22 and 29-31 under 35 U.S.C. 102(b) as being anticipated by Laker (US Patent 3,738,880). The Examiner has rejected claims 23-25 under 35 U.S.C. 102(b) as being anticipated by Carley (US Patent No. 3,980,507). The Examiner has rejected claims 5, 9, 10 and 18 under 35 U.S.C. 103(a) as being unpatentable over Laker and Nihonmatsu et al. (US Patent No. 6,346,485).

Overview

Embodiments of the present invention are methods to alter the etch selectivity of crystalline films by modifying the lattice energy of the film. According to embodiments of the present invention, a crystalline film to be etched is provided. The crystalline film has symmetrical lattice or a "degenerate" lattice. Dopant atoms are then placed into a portion of the crystalline film and the film heated to a sufficient energy to cause the dopants to substitute with atoms in the crystalline film. Utilizing dopant atoms which have a sufficiently different size than the atoms of the crystalline film causes a distortion of the lattice and makes the lattice non-symmetric or "non-degenerate". Making a portion of the lattice non-degenerate causes a thermodynamic stabilization or lattice "energy dump" in the lattice and makes the non-degenerate portion stronger and more difficult to etch. The more stable non-degenerate lattice portion has a higher activation barrier for an etchant than does the unaltered degenerate portion of the film. The difference in the activation energy

barriers between the degenerate lattice portion and the non-degenerate lattice portion of the crystalline film can be exploited by utilizing an etchant which has a sufficiently high activation energy to etch away the degenerate lattice portion of the crystalline film but not a high enough activation energy to etch away the non-degenerate lattice portion of the crystalline film. In this way, the degenerate lattice portion of the film can be etched away without etching the non-degenerate portion of the film resulting in a very high selectivity etch process. The present invention can be used to provide a selectivity of greater than 100:1. That is the present invention enables the degenerate portion of the film to etch over 100 times faster than the non-degenerate portion of the film with a particular etchant. Such an etch selectivity can be exploited to enable a maskless etching of films and enable an anisotropic etch of films utilizing a wet etchant. Such a process can be valuable in the patterning of crystalline films, such as semiconductor films used to form fins or bodies of a fin FET or nonplanar device and/or can be used to remove a crystalline sacrificial gate electrode during a replacement gate process (in both planar and non-planar devices). Other uses of the selective etching of a crystalline film, such as the selective etching of the high dielectric constant dielectric film used as a gate dielectric will become obvious from the description of the present invention.

Claims 1-12 and 29-31

In claims 1-12 and 29-31, Applicant teaches and claims a method of patterning a crystalline film. Applicant claims to place dopant atoms into a first region of the crystalline film whereby the dopant atoms make the portion of the crystalline film in the first region nondegenerate or less degenerate than the crystalline film which was not doped (second region). An etchant is then used to etch away the second region without etching the first region. In claims 11-12 and 29-31, Applicant further claims that the dopant atoms are "charge neutral" with respect to the crystalline film. For

example, a silicon crystalline film can be doped with carbon atoms without altering the conductivity type of the silicon film.

Applicant understands both Laker and Carley to dope the silicon film with dopants which change the conductivity type of the film (i.e., uses dopant atoms which are not charge neutral). That is, Applicant understands Laker to dope an intrinsic polysilicon film 20 with boron atoms, (p type impurities) to form a p type region 28. The silicon layer 20 is then exposed to an etchant which removes the intrinsic silicon and not the p type region 28. As such, Laker dopes the silicon region with p type impurities and not charge neutral impurities as claimed by Applicant.

Similarly, Carley dopes a polycrystalline silicon film 18 with boron atoms (p type impurities) and phosphorous atoms (n type impurities) to form p type region 38 and n type regions 34 and 36. An etchant is then used to remove the n type regions 34 and 36 without removing the p type region 38. As such, Carley, like Laker, utilizes dopants which alter the conductivity type of the film, (to an n type or p type), and does not utilize charge neutral dopants as claimed by Applicant.

As such, for the above mentioned reasons it is Applicants understanding that neither Laker nor Carley teach Applicant's invention as claimed in claims 1-12 and 29-31. As such, Applicant, respectfully, requests the Examiner to remove the 35 U.S.C. § 102(b) rejection of claims 1-12 and 29-31 and seeks an early allowance of these claims.

Claims 14-16

With respect to claims 14-16, Applicant teaches and claims to dope the crystalline film with atoms which are "physically larger" than the atoms which make up the crystalline film. That is, in claims 14-16 Applicant teaches to add dopants to a crystalline film which are larger than the atoms of the crystalline film and then to

remove the portion of the crystalline film which was not doped by the physically larger atoms.

As set forth above, in both Laker and Carley, a polycrystalline silicon film is doped with boron atoms and the portion not doped by boron atoms is then removed. It is to be appreciated that boron atoms are physically smaller than the silicon atoms which make up the polycrystalline silicon films 20 (Laker) and 18 (Carley). As such, it is Applicants understanding that the cited references fail to teach Applicant's invention as claimed in claims 14-16. Applicant, therefore, respectfully requests the removal of the 35 U.S.C. § 102(b) rejections of claims 14-16 and seeks and early allowance of these claims.

Claims 23-25

With respect to claims 23-25, Applicant teaches and claims a method whereby a crystalline film having a nondegenerate lattice is doped with atoms to produce a degenerate lattice portion or a less nondegenerate lattice portion and then the degenerate or less nondegenerate portion etched away. That is, in claims 23-25, a crystalline film having a nondegenerate lattice is first provided. A crystalline film having a nondegenerate lattice can be formed by substituting dopants of a larger or smaller size into a crystalline lattice having a symmetrical structure to distort the lattice and give it a lower thermodynamically more stable lattice energy. For example, the starting nongenerate crystalline film can be a silicon crystalline film having boron atoms substituted with silicon atoms in the lattice to provide a crystalline film having a nondegenerate lattice. Atoms or dopants having similar size to the atoms of the lattice can then be substituted with the dopant atoms in the nondegenerate lattice to make the portion of the crystalline film degenerate or less nondegenerate. For example, silicon atoms can be implanted into the boron doped silicon crystalline film and substituted for boron atoms to make the silicon film

degenerate or less nondegenerate. The degenerate lattice or less nondegenerate lattice portion can then be removed with an appropriate etchant. In this way, the unaltered nondegenerate crystalline lattice portion would remain and the altered degenerate or less degenerate lattice portion removed.

It is Applicant's understanding that Laker fails to teach Applicant's invention as claimed in claims 23-25. As set for above, Laker describes diffusing boron atoms into an intrinsic polycrystalline silicon film 20 to form a p type polycrystalline silicon film 28. The intrinsic polycrystalline silicon film 20 has a degenerate lattice while the p type polycrystalline silicon film 28 has a nondegenerate lattice. The intrinsic silicon region (degenerate region) is then removed leaving the p type silicon region 28 (nondegenerate region). Thus, Laker describes implanting dopants into a degenerate lattice to create a nondegenerate lattice and then removing the degenerate portion. Laker fails to teach providing dopants into a nondegenerate lattice to create a degenerate lattice portion and then to remove the nondegenerate portion while leaving the nondegenerate portion as claimed by Applicant.

As such, Laker clearly fails to teach Applicant's invention as claimed in claims 23-25. Applicant, therefore, respectfully requests the removal of the 35 U.S.C. § 102 rejections of claims 23-25 and seeks and early allowance of these claims.

The PTO did not receive the following listed item(s) Check #120

PETITION FOR EXTENSION OF TIME
PURSUANT TO 37 C.F.R. § 1.136 (a)

Sir:

Applicant respectfully petitions pursuant to 37 CFR § 1.136(a) for a one-month extension of time to file this response to the Office Action mailed November 10, 2005. The extended period is set to expire on March 10, 2006. A check in the amount of $120.00 is enclosed to cover the fee for a one-month extension of time.

Pursuant to 37 C.F.R. 1.136(a)(3), applicant(s) hereby request and authorize the U.S. Patent and Trademark Office to (1) treat any concurrent or future reply that requires a petition for extension of time as incorporating a petition for extension of time for the appropriate length of time and (2) charge all required fees, including extension of time fees and fees under 37 C.F.R. 1.16 and 1.17, to Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN

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